DETERMINING THE FRESHWATER RESERVOIR OFFSET ON THE SPOKANE ARM OF LAKE ROOSEVELT USING MUSSEL SHELL (*Margaritifera falcata*)

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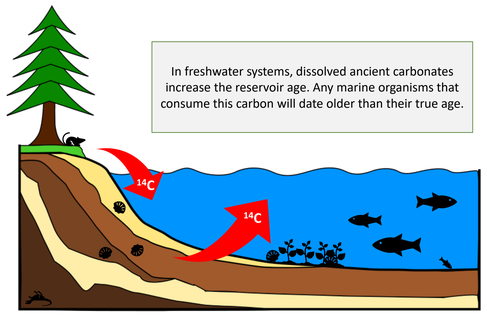
Abstract

Archaeological sites along the Spokane Arm of Lake Roosevelt (formerly the lower Spokane River) commonly contain archaeological shell remains from the freshwater bivalve *Margaritifera falcata*. This organism was exploited by indigenous people as a food source up until the damming of the Spokane River in the early 20th century (Casserino 2017a). Often, freshwater shell is the only potentially datable material recovered during a testing or recovery project. Previous archaeologists working for the Spokane Tribe of Indians Preservation Program (STIPP) used mussel shell for AMS radiocarbon dating. However, none of the dates ever agreed stratigraphically with organic carbon samples that were dated from the same excavation units (Harrison 2014; Jones 2012). A good example of this is an organic:shell paired sample that produced ages of 120 ± 30 14C BP and 2100 ± 30 14C BP, respectively. The cause of this disagreement between organic carbon dates and shell dates lies in what is known as the freshwater reservoir effect (FRE). This poster presents the results of a multi-site, pairwise comparison and demonstrates that shell ages on the Spokane Arm are ~ 2045 years older than their true age.

FRE/FRO

The FRE occurs when ancient carbon becomes pooled in water bodies and is taken in by and incorporated into the structure of marine organisms. This phenomenon can be passed onto and detected in the remains of consumers of marine organisms (Keaveney and Reimer 2012). When a marine shell (*M. falcata*, in this case) is dated through radiocarbon assay, this misleading abundance of ancient carbon skews the date much older than the true date (Hart et al. 2013). Researchers in southeastern Washington State have recorded discrepancies of approximately 2000 to 3000 years (Davis et al. 2021; Osterkamp et al. 2014). To correct this, a freshwater reservoir offset (FRO) can be calculated and applied to better approximate the correct date from shell. If available, a series of diachronic, paired samples from a single context may be used to compute a reference regression from which one can determine the true approximate ages of shell samples across a broad time span. This regression can then be used to estimate more accurate ages from sites which contain shell, but no organics (Osterkamp et al. 2014).



In freshwater systems, dissolved ancient carbonates increase the reservoir age. Any marine organisms that consume this carbon will date older than their true age.

Methods

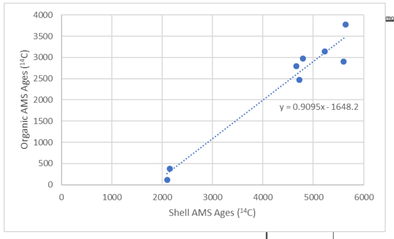
The samples for this project were selected from five previously excavated archaeological sites located along an 11.5 mile stretch of the lower Spokane River between Little Falls Dam and the Spokane-Columbia River confluence at Two Rivers (Casserino 2017b). Radiocarbon dates and relative dates from projectile points recovered at these sites show an occupation range beginning as early as 8,000 years BP and continuing into the post-contact period. Twenty-two dates (eleven pairs) were obtained for this project. Six samples had been previously dated on a project-by-project basis, whereas 16 additional samples were dated specifically for this study. The six previously dated samples were originally reported by Casserino (2018, 2019, 2021) and Harrison (2014). Nine of the organic samples were charcoal or wood, two were mammalian faunal bone. All 11 shell samples were *M. falcata*. Beta Analytic laboratory was chosen as the AMS radiocarbon dating provider for the sake of consistency, as Beta had provided the existing AMS dates on all but one of the past excavation samples. This was desirable, as there would be consistency in the pretreatment process, analytic equipment, date calibration, and reporting standards. One previously provided date was obtained from the University of Arizona AMS facility. Of the twenty-two ages obtained, six were excluded from the study for being in likely secondary contexts. The resulting AMS dates from the shell and organic carbon pairs were compared and the amount of FRO was calculated for each pair. A paired t-test was used to compare the differences between the AMS radiocarbon dates between organic and shell samples. This was followed by an inter-site comparison to distinguish if a geographic difference in FRE existed within the study area. Finally, a linear regression analysis was conducted to predict the corrected age of the shell samples. This was conducted on the radiocarbon (14C) age determinations and then calibrated using INTCAL20 with OxCal Ver 4.4 (Bronk Ramsey 2009).

Results

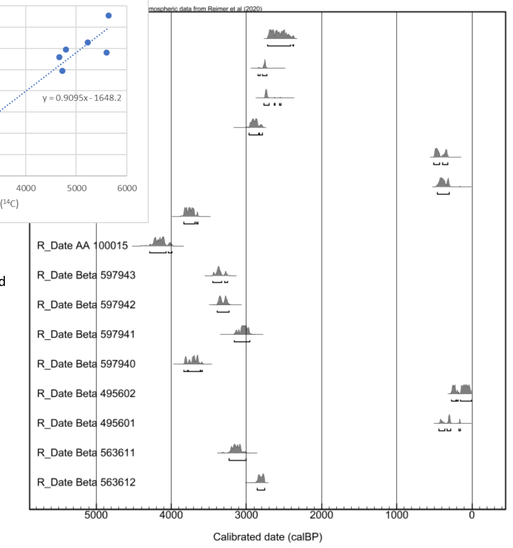
A paired t-test of the eight pairs of usable calibrated dates was performed and the resulting t-statistic (t=18.70, df=7) showed that the FRE produced a highly significant change in AMS radiocarbon dates between organic and shell samples (p <.01). The calculated mean of difference between the inorganic carbon (shell) dates and the organic carbon (charcoal, bone) dates was 2042 years, with a 95 percent confidence interval of 2300-1784 years, or an FRO of -2042 ± 258 years. Inter-site comparison of the average pair differences per site resulted in a mean of 2014.2 and standard deviation of 212.2. Thus, the inter-site difference was within the mean and standard deviation of the group as a whole. Results of the linear regression indicate a significant relationship (p <.01) between the shell and organic AMS ages (R2 = 0.9095 ± 0.08). The resulting equation (Figure 2) is 0.9095*x - 1648.2 where x is the shell age. This can then be used to predict the corrected age for each shell sample. The final step of the analysis was to calibrate the 14C age determinations and compare the results. This analysis indicates that the correction, when applied, produces shell age determinations of the same approximate ages as their paired organic ages (Table 2; Figure 3). A paired t-test performed to test whether the final correction showed any differences and the resulting t-statistic (t=0.015, df=7) showed no significant difference between organic AMS radiocarbon dates and the corrected shell ages samples (p = 0.98).

Calibrated Corrected Shell Ages with Paired Organic Samples

Laboratory Code	Material	AMS Date (14C BP)	Calibrated Age with correction	2σ Age range	Pair Difference
Beta 597937	Bone	2470 ± 30	2568 ± 91	2715 - 2371	
Beta 597936	Shell	4720 ± 30	2764 ± 25	2845 - 2727	196
Beta 471976	Charcoal	2790 ± 30	2889 ± 45	2963 - 2785	
Beta 597946	Shell	4660 ± 30	2725 ± 45	2764 - 2542	164
Beta 597935	Charcoal	380 ± 30	422 ± 59	504 - 319	
Beta 597934	Shell	2150 ± 30	381 ± 46	460 - 299	41
AA 100015	Wood	3778 ± 40	4153 ± 75	4291 - 3988	
Beta 597931	Shell	5640 ± 30	3756 ± 50	3837 - 3645	397
Beta 597943	Charcoal	3140 ± 30	3359 ± 48	3447 - 3255	
Beta 597942	Shell	5230 ± 30	3315 ± 46	3390 - 3234	44
Beta 597941	Charcoal	2900 ± 30	3039 ± 55	3158 - 2954	
Beta 597940	Shell	5600 ± 30	3713 ± 64	3829 - 3589	674
Beta 495602	Charcoal	120 ± 30	131 ± 79	271 - 10	
Beta 495601	Shell	2100 ± 30	316 ± 80	435 - 151	185
Beta 563611	Charcoal	2970 ± 30	3136 ± 57	3233 - 3004	
Beta 563612	Shell	4790 ± 30	2808 ± 31	2860 - 2756	328



↑ Linear Regression Analysis of paired shell samples



➔ Calibrated Age determinations using OxCal Ver 4.4 (Bronk Ramsey 2009)

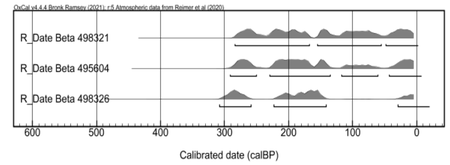
Discussion

The goal of this project was to determine the FRO for use in more accurately dating freshwater shell samples recovered from archaeological contexts on the Spokane Arm of Lake Roosevelt. Although only eight pairs of dates could be used for the analysis, a corrective measure was obtained. This study showed that the amount of FRO for the study area is -2042 ± 258 years. While broad, this correction is still useful. For instance, at one site the AMS age of 2040 ± 30 14C BP when calibrated and corrected, dates to 190 ± 84 cal BP, which is in line with charcoal and bone samples from the same elevation (150 and 170 ± 30 cal BP, respectively). Another example of the utility of the FRO comes from a faunal bone that was thought to be out of context. However, when compared to the calibrated and corrected shell ages, appears that this bone was in correct stratigraphic position. While the dataset for this project was small, the resulting FRO appears to work as a broad FRE corrective measure. There is no contradictory outcome when the offset is applied to existing data, such as the two examples referenced above. Data points from future excavations should help to reduce this amount of error, allowing for a more precise estimation of the true dates obtained from shell samples that have no organic carbon counterparts. It is a goal of the STIPP to continue to date paired shell and organic carbon samples from future excavations to enlarge the data set and determine a more precise offset to use for standalone freshwater shell dates.

Material	^{14}C Date (B.P.)	Calibrated Date (B.P.)	Beta #
bone	150±30	143±84	498321
charcoal	170±30	156±86	495604
shell	2040±30	190±84	498326

➔ Corrected and calibrated ages from level 1 of an excavation, showing agreement with corrected ages

➔ Graphic showing agreement of corrected and calibrated age determinations using OxCal Ver 4.4 (Bronk Ramsey 2009)



Depth (cm)	Previous Uncorrected Date	Sample Type	2021 Corrected Date (bold)
10–20	285 BP, 150 BP	Charcoal	285 BP, 150 BP
40–50	500 BP	Charcoal	500 BP
60–70	4775 BP	***Mussel Shell***	***2695 BP***
80–90	2770 BP	Animal Bone-out of context?	2770 BP
100–110	6180 BP	***Mussel Shell***	***3973 BP***
120–130	6295 BP	***Mussel Shell***	***4077 BP***

➔ Animal bone originally suspected to be out of context now fits in the chronologically correct position.

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